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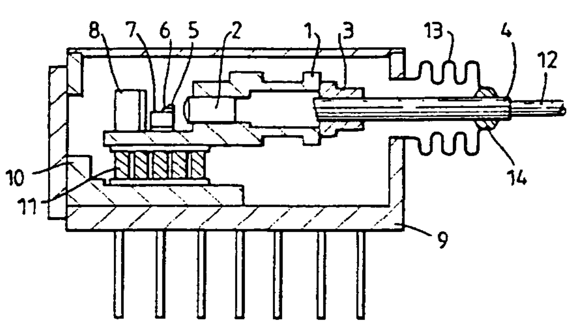
(54) Laser diode module with pigtail fiber.

(57) A laser diode module in which a laser diode chip (5) and an optical fiber pig-tail (12) adjusted in optical axis relative to this laser diode are loaded on a package (9), and a ferrule (4) provided at the tip end of the optical fiber pig-tail is fixed at the lateral wall of this package, the package and the ferrule being coupled via a bellows (13). The bellows absorbs a relative displacement in the axial direction of the ferrule, which is caused between the package and the ferrule by the fluctuation of the ambient temperature, thereby to prevent the optical axes of the laser diode chip and the ferrule from being misaligned.

Fig. 2.



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The present invention relates to a laser diode module, and more specifically to a laser diode module in which the optical axes of a laser diode and an optical fiber pig-tail are ach relatively adjusted.

A laser diode (hereinafter referred to as "LD") module used in optical fiber communication is often marketed in the form of a module provided with an optical fiber pig-tail guiding light output power and is used under an extensive environmental condition ranging from the low to high temperatures.

Fig. 1 illustrates a longitudinal cross section of a conventional LD module. A laser diode (LD) chip 5 is adjusted in optical axis relative to a ferrule 4 via a lens 2 and the ferrule 4 is fixed to a base 1 via a slide ring 3 by YAG laser welding. An optical fiber 12 is protected at a proximate end by a ferrule 4 which is a metal pipe hermetically surrounding the optical fiber. The base 1 is fixed to a pakage 9 by soldering, with a Peltier element 11 interleaved therebetween. The ferrule 4 is fixed to the end wall of the package 9 by a solder lib in a manner to be hermetically sealed.

Since the LD module is usually used under an extensive environmental condition ranging from -20 °C to + 70°C , within this range, it is required to retain a stable performance. The conventional package arranged as above expands about 60μm in the axial direction of the fiber within the atmosphere of + 70°C as compared with a case under the normal temperature (25 °C). This displacement causes mechanical movement of the ferrule 4 fixed by a solder 14. When the ferrule 4 receives such a force, the base 1 would be deformed by being pushed by the ferrule, causing a deviation of the optical axes for the LD chip 5 and the ferrule 4. As a result, the optical output power launched into the optical fiber 12 within the ferrule 4 fluctuates 1dB or more. This phenomenon will also occur under the environmental condition of -20 °C, and yet in the opposite direction, thereby to cause a fluctuation of the optical output power. That is, the conventional LD module has a drawback that its optical output power fluctuates by the fluctuation of the environmental temperature.

Accordingly, an object of the present invention is to eliminate such drawback discussed above and provide a laser diode module which allows a stable optical output power to be achieved even for the fluctuating environmental temperature.

According to the present invention, there is provided a laser diode module comprising a package having first and second ends, a laser diode chip accommodated therein and a ferrule provided at the end of an optical fiber fixed to the laser diode chip at a predetermined optical position, the ferrule being supported near the first end of the package at its one end and, at the other end, extending through an aperture provided at the first end of the package, a bellows through which center hole the ferrule extends, and fixed to the package at its one end and fixed to the ferrule at the other end.

In a preferred embodiment of the pres nt invention, the LD module has a base fixed to the package, and the ferrule is fixed to this base at its one end and is coupled to the package at the other end via the bellows.

In the preferred embodiment of the present invention, the ferrule may be divided into two portions so that the first portion is fixed to the base and the second portion is coupled to the package via the bellows.

That is, in the laser diode module according to the present invention, since the package and the ferrule are coupled via the bellows, even under the environmental condition ranging from the low to high temperatures, a stable optical output can be coupled without the optical axes of the laser diode and the optical fiber pig-tail being misaligned.

The present invention will be clearly understood from the following description with reference, by way of example, to the accompanying drawings, in wich:-

Fig. 1 is a longitudinal cross section of a conventional laser diode module;

Fig. 2 is a longitudinal cross section of a laser diode module according to a first embodiment of the present invention; and

Fig. 3 is a longitudinal cross section of a laser diode module according to a second embodiment of the present invention.

Fig. 2 illustrates a longitudinal cross section of a laser diode module according to a preferred embodiment of the present invention. A base 1 supports a lens 2 at its one end and one end of a ferrule 4 at the other end via a slide ring 3 fixed to the base 1 by means of an YAG laser welding. In addition, the base 1 is provided with an extension for supporting a laser diode chip 5, a heat sink 6, a chip carrier 7 for supporting these and a photodiode 8. The LD chip 5 is adjusted in optical axis relative to the ferrule 4 via the lens 2.

The extension of the base 1 is opposed to an L-shaped member 10 of the package 9 at a predetermined interval, and a Peltier element 11 is disposed therebetween. The Peltier element 11 is fixed to the base 1 and the package 9 by means of soldering.

The ferrule 4 at the tip end of the optical fiber pigtail 12 extends outwardly through the aperture of the package 9. One end of the bellows 13 is fixed to the package about its aperture, extending coaxially with the ferrule 4, and its tip end is hermetically sealed to the outer peripheral surface of the ferrule 4 via a solder layer 14.

The bellows 13 is, for example, an electroplated bellows formed of a multilayer film of Au, Ni and Cu and, in this embodiment, it has three crests and its spring constant assumes 0.1 kg/mm.

If the LD module arranged as above is used under the environmental condition fluctuating between -20°C and + 70°C, the package 9 is deformed about 60

μm in the axial direction of the ferrule 4 due to thermal expansion/contraction. This deformation in turn causes a relative displacement corresponding thereto between the bellows 13 fixed to one end of the package and the ferrule supported to the other end of the package. This displacement is absorbed by expansion and contraction of the bellows 13. If the spring constant of the bellows is on the order of 0.1 kg/mm or less, then a mechanical stress is hardly applied to the ferrule 4 and the deformation of the package 9 is absorbed by the bellows 13. In consequence, the optical axes of the LD chip and the ferrule cannot misalign.

Fig. 3 illustrates a longitudinal cross section of a second embodiment of the present invention. This LD module differs from that of Fig. 2 in that the ferrule 4 is divided into a first and second ferrules 41 and 42, which are both coupled by a bellows 13a. The second ferrule 42 constitutes a hermetic sealing portion of the package. The bellows 13a may be an electroplated bellows as in foregoing but, in this embodiment, it is a single Ni layer having two crests and its spring constant assumes 0.1 kg/mm.

The first ferrule 41 is adjusted in optical axis relative to the LD chip 5, and is fixed to the base 1 via the slide ring 3 by YAG laser welding, while the second ferrule 42 is fixed to the package 9 by the solder layer 14, as in the conventional LD module of Fig. 1.

In the LD module according to the second embodiment, since the ferrule is divided into two portions, the deformation wihtin the range of -20°C and + 70°C is absorbed by the bellows 13a which spring constant is small and, as in the first embodiment, a stable coupling can be retained against the fluctuating temperature.

Claims

1. A laser diode module comprising: a package (9) accommodating a laser diode chip (5) therein; an optical fiber (12) having one end optically coupled to said laser diode chip within said package, the other end of said optical fiber being led out from said package through a hermetic sealing portion (14); a ferrule (4) provided at said one end of an optical fiber; one end of said ferrule being supported by a supporting member (1,3) located within said package; a bellows (13) fixed to the other end of said ferrule, the other end of said bellows being fixed to said hermetic sealing portion.

2. A laser diode module according to claim 1, wherein said supporting member (1) comprises a slide ring (3) supported by a base (1) fixed to said package.

3. A laser diode module according to claim 2 wherein said ferrule is divided into first and second portions (41,42) one end of said first portion (41) is supported by said slide ring and the other end of said first portion is fixed to one end of said bellows, one end of said second portion (42) is fixed to said other end of said bellows, and the other end of said second portion is fixed to said package.

4. A laser diode module according to any preceding claim, wherein said bellows is an electroplated bellows formed of a multilayer film consisting of Au, Ni and Cu.

5. A laser diode module according to any preceding claim, wherein said bellows is an electroplated bellows formed of a single Ni layers.

6. A laser diode module according to any preceding claim, wherein said bellows has a spring constant of 0.1 kg/mm or less.

Fig.1.
(PRIOR ART)

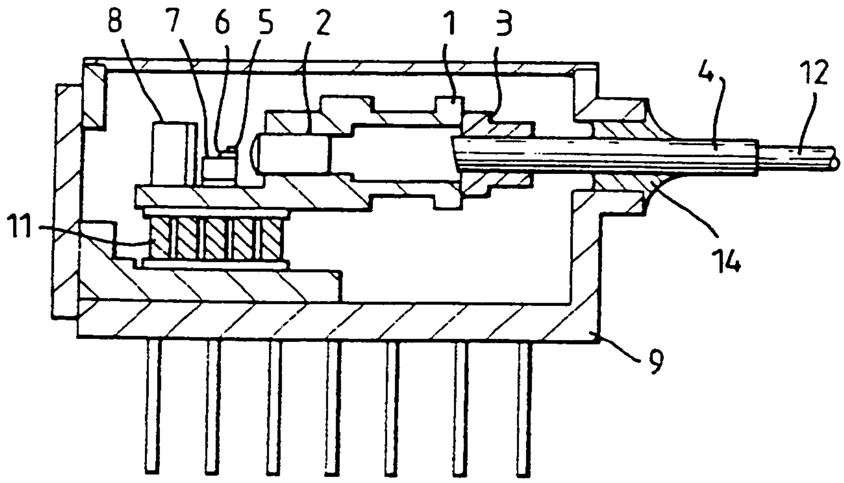


Fig. 2.

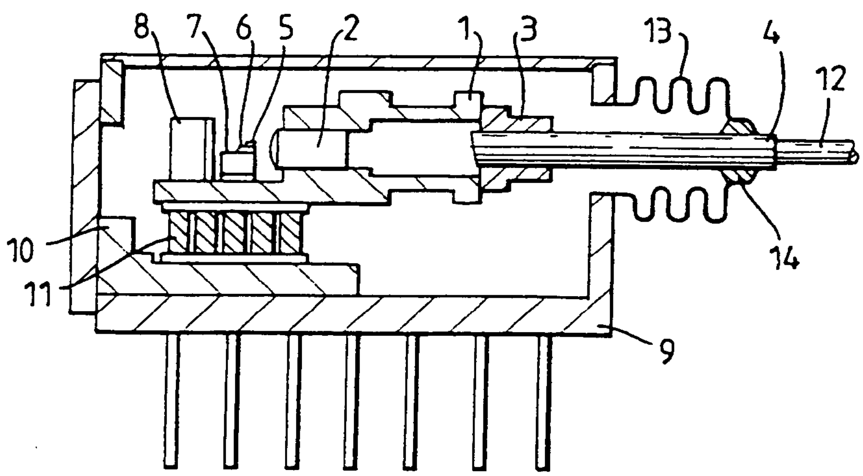
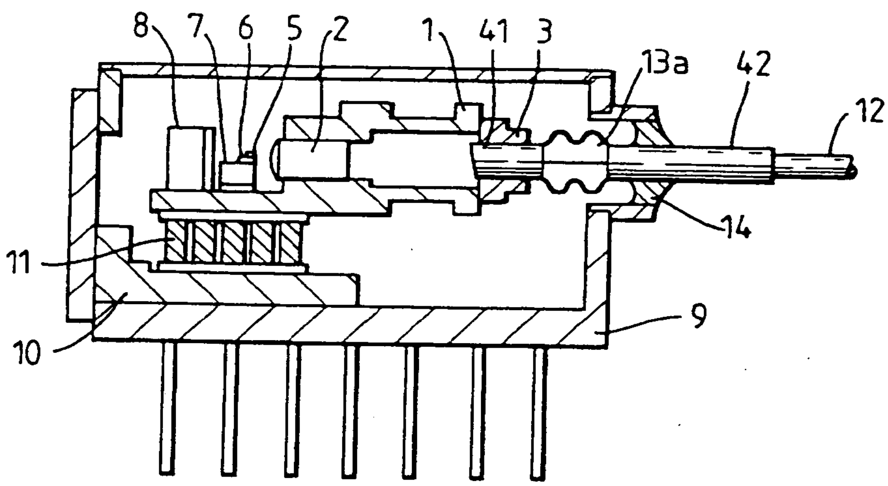


Fig. 3.



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EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0099

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	PATENT ABSTRACTS OF JAPAN vol. 6, no. 189 (E-133)(1067) 28 September 1982 & JP-A-57 100 781 (FUJITSU) 23 June 1982 * abstract *	1	G02B6/42
Y	EP-A-0 259 018 (AMP INCORPORATED) * abstract; figures 2,3,9,10 * * column 9, line 36 - column 10, line 15 *	1	
A		2,3	
A	PATENT ABSTRACTS OF JAPAN vol. 5, no. 44 (E-50)(716) 24 March 1981 & JP-A-55 166 972 (MITSUBISHI) 26 December 1980 * abstract *	1	
A	US-A-4 192 574 (HENRY ET AL.) * abstract; figures 2,3 * * column 2, line 3 - line 18 * * column 2, line 57 - line 65 *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	28 JANUARY 1992	HYLLA W.

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